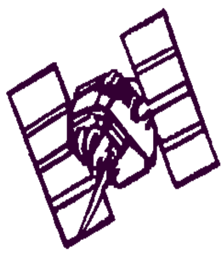
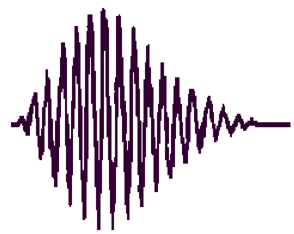
U.S. COAST GUARD

RADIONAVIGATION BULLETIN

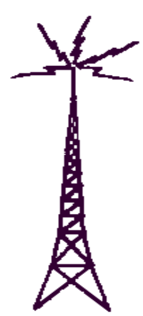
Spring/Summer Issue 2000, Number 34



DGPS/GPS



LORAN-C



RADIOBEACONS

From the Commanding Officer...

As I look through this bulletin in draft, I'm impressed with all the activities and developments that have occurred since the last edition…then I realize its been about two years since the previous bulletin was published.

So let's get caught up. As many of you know I relieved CAPT Doherty last June and stepped into one of the most challenging assignments of my career… and one of the most exciting ashore. At that time, NAVCEN was just catching a breather after achieving Full Operational Capability for the Maritime DGPS system. The future of Loran was in question and the final details for the third civil signal for GPS was nearing completion.

Since then, we have been moving forward on many fronts. Without stealing anyone's thunder in the articles that follow, I'll highlight a few developments and leave the details to the contributing authors.

NAVCEN initiated two important projects last summer that we hope will create greater efficiency and relevancy within the Loran community. They are the in-house Training Review that is headed up by the Executive Officer, CDR Dave Masiero, and the Reorganization Proposal for NAVCEN.

All three systems (GPS, DGPS and Loran-C) came through the End of Week Rollover and Y2K events with no discrepancies or reported outages.

The Federal Radionavigation Plan (FRP) for 1999 was released in February. In this document that sets radionavigation policy for the government is stated, "While the administration continues to evaluate the long-term need for continuation of the Loran-C radionavigation system, the Government will operate Loran-C in the short term". Presently, Loran-C is being evaluated for providing a supplemental source of radionavigation to overcome vulnerabilities of GPS. The next edition of the FRP is due out in 2001. In the meantime, Loran Modernization has begun in earnest, starting with the careful planning to replace our remaining tube transmitters with solid state upgrades.

At the Civil GPS Service Interface Committee meetings in Nashville (in SEP '99) and Fairfax (in MAR '00) we saw an ever expanding circle of users and providers from many nations throughout the world in attendance in the interest of navigation and timing. The new and innovative uses of GPS and DGPS is staggering.

In partnership with the Loran Support Unit, we are conducting a Prototype Automated Loran Station (PALS) test. This six month trial will define whether we can technically operate a solid state LORSTA remotely. If this is proven successful, it will move us one step closer to demanning LORSTAs.

The establishment of Nationwide DGPS sites continues with the latest site coming on line in Macon, GA.

Probably the most exciting development is the announcement earlier this month that Selective Availability will be set to zero, increasing the accuracy of GPS for civil users from 100 meters to better than 20 meters. This is a milestone in navigation for sure. Included in this bulletin are Q&As concerning DGPS in light of SA being turned off. The debate has already started concerning the future need for DGPS. Suffice it to say that there are two primary categories of "need" that will keep DGPS on-line until something else occurs…those that need better than 20 meter accuracy, i.e. surveyors, train control, highway safety (including snow plowing), etc. and the general need for integrity monitoring of the GPS system.

As you can gather, there is an exciting and lively landscape out there in the world of Radio Navigation, and there are many more challenges yet to come. We will exercise due diligence in keeping to a semiannual schedule in preparing and distributing this bulletin. We welcome your comments and contribution of articles to make this truly a forum for discussion of technological advancement and policy change.

Here's to safe navigation and an accurate clock!

CAPT Tom Rice

U.S. Coast Guard
Navigation Center
7323 Telegraph Rd.
Alexandria, VA 22315-3998

Issue Number 34
Spring/Summer 2000

ADM J. M. Loy
Commandant

VADM J. C. Card
Vice Commandant

RADM T. M. Cross
Assistant Commandant for Operations

RADM K. T. Venuto
Director of Operations Policy

CAPT C. T. Lancaster
Chief, Office of Aids to Navigation

CAPT T. R. Rice
Commanding Officer, Navigation Center

LTJG P. B. Jones
Editor

The *Radionavigation Bulletin* contains radionavigation system-related items for interested persons. This bulletin shall not be considered as authority for any official action and is non-record material. Views and opinions expressed do not necessarily reflect those of the Department of Transportation or the U.S. Coast Guard.

Contributors: Articles are welcome from all parties. Articles for publication should be sent to: Commanding Officer, USCG NAVCEN, 7323 Telegraph Road, Alexandria, VA 22315-3998. Articles may be submitted typewritten in 10 or 12 characters per inch, on an IBM-PC compatible 3.5 inch floppy disk (returned on request), or electronically mailed to *rnb@navcen.uscg.mil*. The *Radionavigation Bulletin* staff reserves the right to edit all material submitted. Copyrighted material will not be accepted without the author's and/or publisher's written release/permission.

Readers: We welcome your comments. Critiques, complaints and distribution concerns should be directed to the above address.

RADIONAVIGATION BULLETIN

Table of Contents

Coast Guard SDL No. 137

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
A	1	1	1		1	1	1	1	1	1		1	1	1	1	1	1		1		2					
B		10	10	3	10	2	2	5	5	2	5	3	3	3	3	2	1	5	3	1	1		2	2	5	1
C	5	3	1	5	2	3	3		1	1	3	2	1	5	1		1	1	1	1	1	2	2	1	1	1
D	1	1	1	2	1	1		1	1	1	1	1	1		1	1			1	2	1	1	1			1
E	1		1				1	1		1	1	1	1	1	1				1	1		1	1			
F																	1	1	1							
G	1	1	1	1	1																					
H																										

NON-STANDARD DISTRIBUTION: CG-31 (1), CG-56 (1), CG-64 (1)

President Discontinues Selective Availability!

STATEMENT BY THE PRESIDENT REGARDING THE UNITED STATES' DECISION TO STOP DEGRADING GLOBAL POSITIONING SYSTEM ACCURACY

May 1, 2000

Today, I am pleased to announce that the United States will stop the intentional degradation of the Global Positioning System (GPS) signals available to the public beginning at midnight tonight. We call this degradation feature Selective Availability (SA). This will mean that civilian users of GPS will be able to pinpoint locations up to ten times more accurately than they do now. GPS is a dual-use, satellite-based system that provides accurate location and timing data to users worldwide. My March 1996 Presidential Decision Directive included in the goals for GPS to: "encourage acceptance and integration of GPS into peaceful civil, commercial and scientific applications worldwide; and to encourage private sector investment in and use of U.S. GPS technologies and services." To meet these goals, I committed the U.S. to discontinuing the use of SA by 2006 with an annual assessment of its continued use beginning this year.

The decision to discontinue SA is the latest measure in an on-going effort to make GPS more responsive to civil and commercial users worldwide. Last year, Vice President Gore announced our plans to modernize GPS by adding two new civilian signals to enhance the civil and commercial service. This initiative is on-track and the budget further advances modernization by incorporating some of the new features on up to 18 additional satellites that are already awaiting launch or are in production. We will continue to provide all of these capabilities to worldwide users free of charge.

My decision to discontinue SA was based upon a recommendation by the Secretary of Defense in coordination with the Departments of State, Transportation, Commerce, the Director of Central Intelligence, and other Executive Branch Departments and Agencies. They realized that worldwide transportation safety, scientific, and commercial interests could best be served by discontinuation of SA. Along with our commitment to enhance GPS for peaceful applications, my administration is committed to preserving fully the military utility of GPS. The decision to discontinue SA is coupled with our continuing efforts to upgrade the military utility of our systems that use GPS, and is supported by threat assessments which conclude that setting SA to zero at this time would have minimal impact on national security. Additionally, we have demonstrated the capability to selectively deny GPS signals on a regional basis when our national security is threatened. This regional approach to denying navigation services is consistent with the 1996 plan to discontinue the degradation of civil and commercial GPS service globally through the SA technique.

Originally developed by the Department of Defense as a military system, GPS has become a global utility. It benefits users around the world in many different applications, including air, road, marine, and rail navigation, telecommunications, emergency response, oil exploration, mining, and many more. Civilian users will realize a dramatic improvement in GPS accuracy with the discontinuation of SA. For example, emergency teams responding to a cry for help can now determine what side of the highway they must respond to, thereby saving precious minutes. This increase in accuracy will allow new GPS applications to emerge and continue to enhance the lives of people around the world.

President Bill Clinton

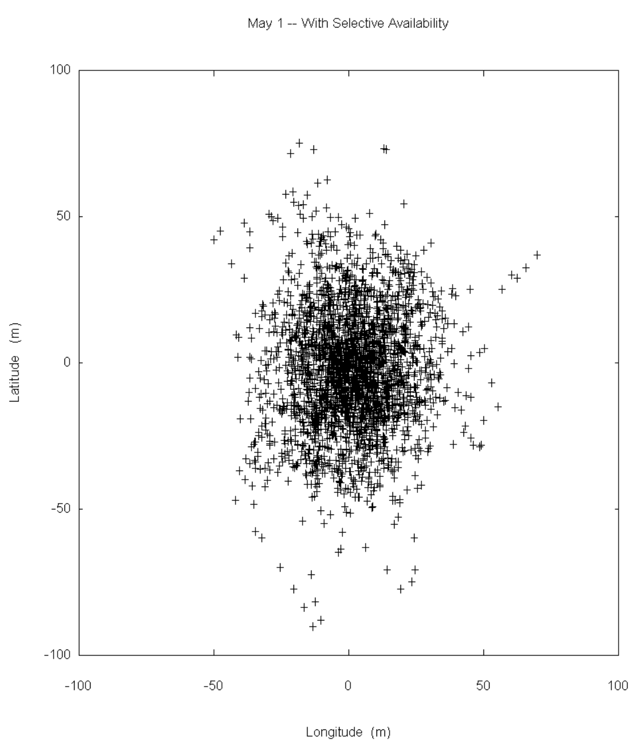
SA Set to Zero — Civil Users Realize Unprecedented Accuracy Worldwide

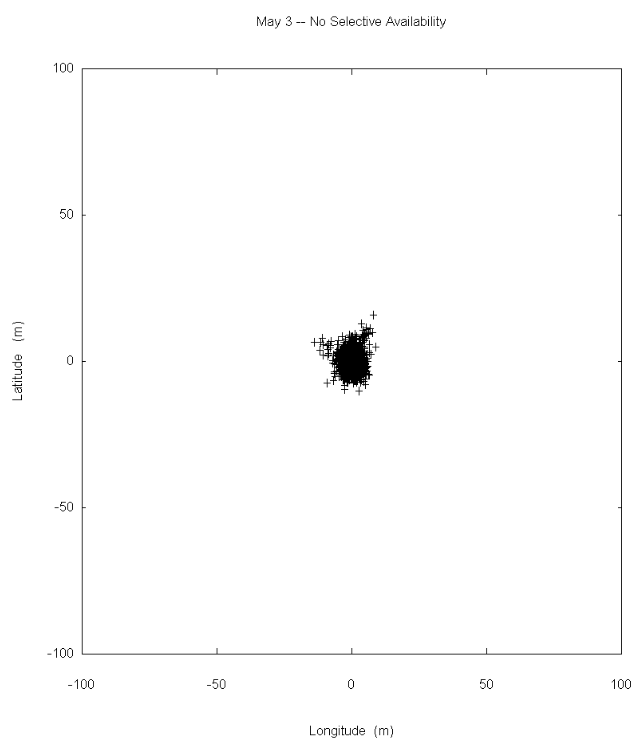
The images compare the accuracy of GPS with and without selective availability (SA). Each plot shows the positional scatter of 24 hours of data (0000 to 2359 UTC) taken at one of the Continuously Operating Reference Stations (CORS) operated by the NCAD Corp. at Erlanger, Kentucky. On May 2, 2000, SA was set to zero. The plots show that SA causes 95% of the points to fall within a radius of 45.0 meters. Without SA, 95% of the points fall within a radius of 6.3 meters.

As illustration, consider a football stadium. With SA activated, you really only know if you are on the field or in the stands at that football stadium; with SA switched off, you know which yard marker you are standing on.

For additional information:

Dr. Dennis G. Milbert
Chief Geodesist
National Geodetic Survey, NOAA
301-713-3222
Dennis.Milbert@noaa.gov





Data taken at the Erlanger National CORS station, National Geodetic Survey, NOAA. Data with SA were taken from 0000 to 2359 UTC on May 1, 2000. Data without SA were taken from 0000 to 2359 UTC on May 3, 2000. Both data sets were taken at 30 second intervals. Instrumentation was an Ashtech Z-12 receiver. GPS data were dual-frequency pseudorange (both L1 and L2) incorporating ionospheric correction. Data were processed in accordance with the GPS Interface Control Document ICD-GPS-200C, using the broadcast orbit parameters in the World Geodetic System WGS 84 (G873) reference system.

Data provided courtesy of IGEB

Improved GPS To Foster Safety, Commerce

GPS is a dual-use system, providing highly accurate positioning and timing data for both military and civilian users. There are more than 4 million GPS users world wide, and the market for GPS applications is expected to double in the next three years, from $8 billion to over $16 billion. Some of these applications include: air, road, rail, and marine navigation, precision agriculture and mining, oil exploration, environmental research and management, telecommunications, electronic data transfer, construction, recreation and emergency response.

GPS IS THE GLOBAL STANDARD. GPS has always been the dominant standard satellite navigation thanks to the U.S. policy of making both the signal and the receiver design specification available to the public completely free of charge.

NEW TECHNOLOGIES ENHANCE AMERICA'S NATIONAL SECURITY. The U.S. previously employed a technique called Selective Availability (SA) to globally degrade the civilian GPS signal. New technologies demonstrated by the military enable the U.S. to degrade the GPS signal on a regional basis. GPS users worldwide would not be affected by regional, security-motivated, GPS degradations, and businesses reliant on GPS could continue to operate at peak efficiency.

GPS IMPROVED SIGNAL WILL BRING INSTANT BENEFITS TO MILLIONS OF GPS USERS. The improved, non-degraded signal will increase civilian accuracy by an order of magnitude, and have immediate implications in areas such as:

- Car Navigation: Previously, a GPS-based car navigation could give the location of the vehicle to within a hundred meters. This was a problem, for example in areas where multiple highways run in parallel, because the degraded signal made it difficult to determine which one the car was on. Terminating SA will eliminate such problems, leading to greater consumer confidence in the technology and higher adoption rates. It will also simplify the design of many systems (e.g., eliminate certain map matching software), thereby lowering their retail cost.

- Enhanced-911: The FCC will soon require that all new cellular phones be equipped with more accurate location determination technology to improve responses to emergency 911 calls. Removing SA will boost the accuracy of GPS to such a degree that it could become the method of choice for implementing the 911 requirement. A GPS-based solution might be simpler and more economical than alternative techniques such as radio tower triangulation, leading to lower consumer costs.

- Hiking, Camping, and Hunting: GPS is already popular among outdoorsmen, but the degraded accuracy has not allowed them to precisely pin-point their location or the location of items (such as game) left behind for later recovery. With 20 meter accuracy or better, hikers, campers, and hunters should be able to navigate their way through unmarked wilderness terrain with increased confidence and safety. Moreover, users will find that the accuracy of GPS exceeds the resolution of U.S. Geological Survey (USGS) topographical quad maps.

- Boating and Fishing: Recreational boaters will enjoy safer, more accurate navigation around sandbars, rocks, and other obstacles. Fishermen will be able to more precisely locate their favorite spot on a lake or river. Lobster fishermen will be able to find and recover their traps more quickly and efficiently.

- Increased Adoption of GPS Time: In addition to more accurate position information, the accuracy of the time data broadcast by GPS will improve to within 40 billionths of a second. Such precision may encourage adoption of GPS as a preferred means of acquiring Universal Coordinated Time (UTC) and for synchronizing everything from electrical power grids and cellular phone towers to telecommunications networks and the Internet. For example, with higher precision timing, a company can stream more data through a fiber optic cable by tightening the space between data packets. Using GPS to accomplish this is far less costly than maintaining private atomic clock equipment.

Additional information about GPS and the Selective Availability decision is available online at the Interagency GPS Executive Board web site: http://www.igeb.gov

Excerpted from White House Press Release

SA Termination Q & A

At what time was SA turned off?

Selective Availability ended a few minutes past midnight EDT after the end of May 1, 2000. The change occurred simultaneously across the entire satellite constellation. *(Note: Previously, we incorrectly reported that SA ended at midnight GMT. We regret the error.)*

Will SA ever be turned back on?

The United States has no intent to ever use SA again. To ensure that potential adversaries do not use GPS, the military is dedicated to the development and deployment of regional denial capabilities in lieu of global degradation.

Do I need to replace my receiver to get the higher accuracy?

No. Existing GPS receivers around the world should be getting the higher accuracy right now without any modifications.

With SA gone, do I still need differential GPS (DGPS)?

It depends on your specific user requirements. If you are using GPS for safety-critical navigation, you will still need to use the Coast Guard DGPS or Nationwide DGPS to get the higher accuracy (1-3 meter) and the integrity monitoring/warning service. If you are a surveyor requiring sub-meter positioning, you will still need some form of DGPS to achieve that level of precision.

On the other hand, if you are a trucking company using GPS to track and manage assets, the <20 meter accuracy now available from the basic civil signal may be sufficient to meet your needs without DGPS augmentations.

Will the Coast Guard continue to operate its DGPS services?

Yes. The U.S. Coast Guard will continue to run the maritime DGPS network to provide the higher accuracy and integrity monitoring/warning service required for safety-critical navigation. In fact, efforts are currently under way to expand the Coast Guard DGPS network across the continental United States to provide the same GPS augmentation service to terrestrial users on railroads and highways. The expanded network is known as the Nationwide DGPS, or NDGPS, service.

Is DGPS more accurate now?

No. There should not be much change in the accuracy of DGPS. However, DGPS corrections may not need to be broadcast as frequently any more. As a result, we may see future commercial DGPS services that use less radio bandwidth and thus cost less to the end user.

I heard that SA will be left on in certain parts of the world. Is it still on in my country?

No. You have been misinformed. Selective Availability was a global degradation of the GPS service. It could not be applied on a regional basis. By turning it off, the President immediately improved GPS accuracy for the entire world. The United States has no intention of reactivating SA ever again.

Users in the U.S. and the rest of the world should now be experiencing the same basic GPS accuracy of 10-20 meters or better.

Is the civilian GPS service now as accurate as the military's Precise Positioning Service (PPS)?

In theory, civil receivers should now match the accuracy of PPS receivers under normal circumstances. We are in the process of collecting data to verify whether this is true. PPS still gives advantages to the military beyond accuracy.

Is the SPS signal specification going to be updated?

Yes. The agencies on the Interagency GPS Executive Board are currently working to revise the Standard Positioning Service (SPS) signal specification to reflect the new accuracy available without SA. This is expected to take several weeks. We will post the updated signal specification to the IGEB web site when it is available.

Courtesy of IGEB

NDGPS Antenna Analysis

Background

The Department of Transportation is coordinating the implementation of a network of Differential Global Positioning System (DGPS) broadcast sites across the continental United States, including Alaska. This broadcast network will provide a standardized signal for DGPS service throughout the country. This Nationwide DGPS (NDGPS) network design is based on the United States Coast Guard DGPS maritime service that began initial operation in 1996 with service coverage of major harbors and coastlines and achieved full operation on 15 March 1999.

A major component of the NDGPS implementation plan is the reuse of United States Air Force (USAF) Ground Wave Emergency Network (GWEN) facilities as NDGPS broadcast sites. This reuse of equipment, either in its current location or moved to new sites, provides the opportunity to utilize assets acquired by USAF to reduce the cost of providing NDGPS coverage. Currently eight GWEN sites have been converted into NDGPS sites with at least 70 more conversions or constructions scheduled over the next several years (Fig. 1).

The standard GWEN site antennas are 290 feet tall and are set on a 5 foot base with insulator. There are twelve Top Loading Elements (TLEs) ranging from 179' to 229' in length, depending on the site, set at an approximate angle of 45 degrees. The ground plane consists of a 24' x 36' copper ground screen with one hundred 100 meter long radials every 3.6 degrees. The result is a broadcast antenna that is approximately 55% efficient, compared to the standard maritime DGPS antenna at only 10 to 15% efficient. These high GWEN antenna efficiencies translate into farther signal ranges at reduced power and costs, important factors in designing a system to ensure nationwide coverage.

The original GWEN antenna design called for operating frequencies of 150 to 175 kHz, unfortunately causing the antennas to be resonant near the DGPS operating frequencies (285 to 325 kHz). This meant most of the antennas are either outside the tuning range of the standard Coast Guard Automatic Tuning Unit (ATU) or just within tuning range, but not allowing the full range of the variable tuning circuit.

USCG Command and Control Center (C2CEN) Radio Frequency (RF) Engineers were assigned the task of developing a solution that would allow all the ATUs to tune to the GWEN antennas. The problem was separated into providing solutions for "Existing GWEN" sites where the antenna was already in place and "New GWEN" sites where an antenna needed to be erected. Also, any proposed design recommendations were required to maintain the high antenna efficiencies and be standardized for all GWEN sites.

Problem

An antenna system's reactance is composed of two parts, the real or resistive component and the imaginary or capacitive/inductive component. For an antenna system to function at peak efficiency the reactance needs to be purely resistive, that is, there should be no capacitive or inductive component. The antenna system's capacitive/inductive reactance is frequency dependant, and when the reactance is purely resistive the antenna is said to be resonant.

An ATU (or antenna coupler) has two functions, the first is to cancel the antenna's capacitive component with a matching inductive component to ensure that the reactance present is purely resistive. The second function is to compensate, via a variable tuning circuit, for any variations in the reactance caused by daily weather changes to ensure that the reactance remains purely resistive.

The GWEN antennas are designed such that they are resonant just above the DGPS operating frequencies. Since an antenna's capacitive reactance is frequency dependant, the closer the operating frequency is to the resonant frequency the less capacitive the antenna is. Also the TLEs on an antenna have a net effect of removing capacitive reactance, so antennas with longer TLEs are less capacitive. This means that for the high frequency sites or those with longer TLEs, the capacitive reactance of the antennas is either negligible, so the ATUs can't tune to the antennas, or is so small that the variable tuning circuit can't use its full range to compensate for the daily variations in antenna reactance. This in turn can cause the transmitter to shut down creating needless "off-air" time (when no DGPS signal is broadcast).

The solution to these tuning problems is to make the antenna's reactance more capacitive at the required frequencies. This can be done in one of two ways, the first is to decrease the overall length of the TLEs, either by shortening each TLE or decreasing the total number of TLEs. The second way is to add a capacitor in series between the ATU and antenna which would increase the capacitance the ATU "sees" and can tune to.

One concern with changing the antenna's reactance so that it is more capacitive, is that more of the ATUs inductive coil needs to be used to match it. As more of the coil is used, the antenna's efficiency diminishes because of the power losses in the inductive coil. Conversely, if too little of the coil is used, then the variable tuning circuit can't use its full range to compensate for daily changes in the reactance, which causes power to be reflected back to the transmitter (high Voltage Standing Wave Ratio – VSWR) causing the transmitter to shut-down. C2CEN engineers determined an optimum setting range that gave the variable tuning circuit enough range to adjust for daily variations while power losses from the coil were kept to a minimum.

reactance and is, again, frequency dependent. The antenna's effective height, which is different then the physical height, is increased with the addition of TLEs, so shortening the TLEs would decrease the antenna's efficiency something the C2CEN engineers wanted to avoid.

Solution

The antenna's capacitive reactance can be changed by decreasing the overall length of the TLEs, either by shortening each TLE or decreasing the total number of TLEs (from 12 to 9 or 6). At new sites the TLE length can be predetermined to ensure the ATU can tune to the antenna. C2CEN Engineers determined this was

Nationwide DGPS

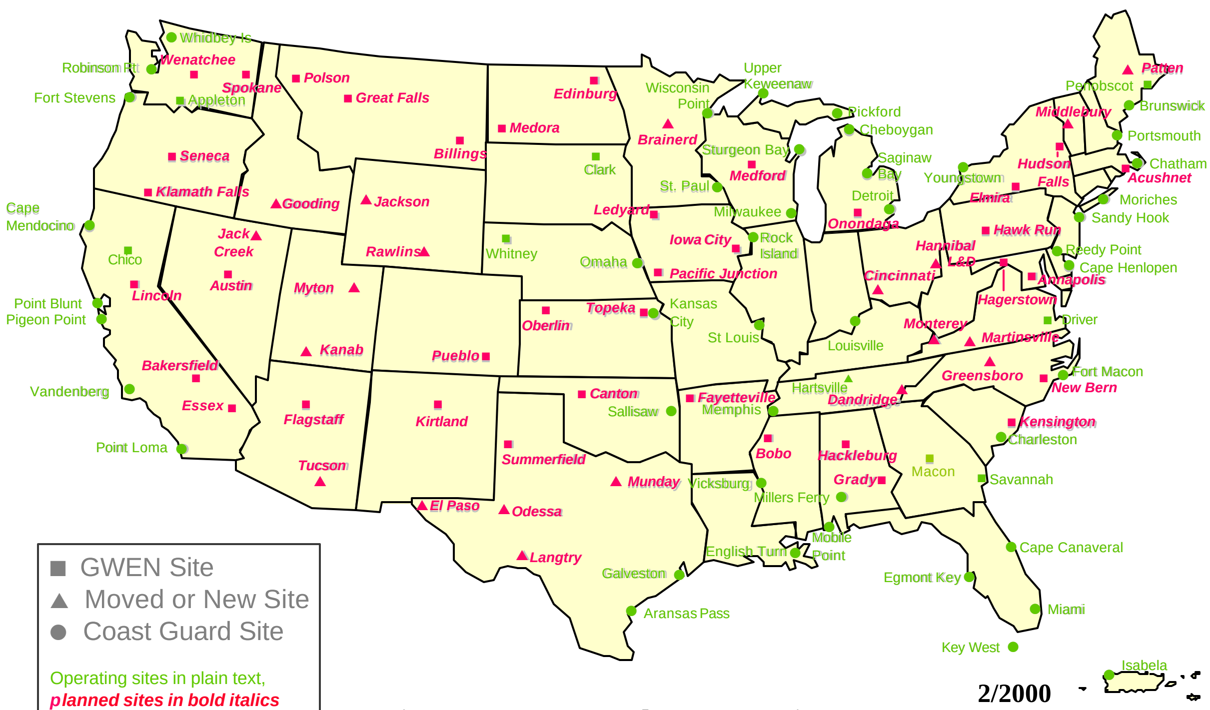


Figure 1: Proposed NDGPS Sites

The other concern with the GWEN antennas is the efficiency. Only part of the transmitter's energy sent to antenna is radiated as broadcast energy, the antenna's efficiency is the measure of how much power is radiated. For an antenna system that is 50% efficient, a transmitter operating at a 1,000 Watts, only 500 Watts of that is radiated as usable signal while the other 500 Watts is lost. The antenna's efficiency is directly dependent upon the effective height of the antenna, which is based upon the towers capacitive

the easiest solution for the new sites and calculated a standard TLE length of 150' (29' shorter than the current shortest TLE length) ensures the ATU could tune to the antenna while maintaining a high efficiency.

At existing sites, changing the length of the TLE is a much more difficult undertaking and would require installing entirely new TLEs and guy wires. At these

(Continued on page 10)

(Continued from page 9)
sites it is much more cost to decrease the number of the TLEs by disconnecting, or dropping, them from the tower, however this solution had numerous drawbacks. First, dropping TLEs would result in lost efficiency requiring more power (and cost) to ensure the coverage zone requirements are met. Second, because the TLEs are a fixed height there is limited control in how much the capacitive reactance could be adjusted. For example, dropping two TLEs may not change the reactance enough, but dropping three TLEs changes it too much requiring the use of more than the optimum value of the tuning coil. Finally, it is very difficult to model the effects of dropping TLEs, such as radiation patterns, so the affect wouldn't be truly known until after the site started transmitting again. If these results are undesirable then the dropped TLEs would have to be reinstalled, creating more down time and increasing the cost.

The other option available, to adjust the capacitive reactance of the antennas, and the one the RF Engineers decided to use at the existing sites was to install a Matching Network between the ATU and the antenna. This Matching Network is comprised of a large in-series capacitor and a shunt coil (inductor) connected to ground. The capacitor's value is calculated to ensure that the capacitive reactance is only changed enough to allow the ATU to effectively match the antenna within the desired tap setting. If the change is too great, and too much of the ATUs coil is used, then it starts needlessly reducing the antenna's efficiency.

Placing a capacitor in series can cause a static DC charge to develop. When this static charge becomes sufficiently large enough it can short across the ATU and cause significant damage. This happened at the Penobscot, ME site in early 1999 causing significant damage to the ATU. The shunt coil is designed to prevent this problem. This inductor, if properly designed, shows a very large resistance (ideally infinite) to the DGPS frequency band, ensuring all the energy is sent to the antenna while being an effective drain to any DC charges that accumulate.

Results

The Matching Network was installed at seven of the eight sites currently in operation (Whitney, NE; Savannah, GA; Chico, CA; Hartsville, TN; Driver, VA; Penobscot, ME and Clark; SD) and have worked as designed. No new sites have been built since C2CEN's analysis but we are awaiting the results of the first site installation to validate the calculations.

LT Dave Godfrey, C2CEN

RF Working Group Aids DGPS

During 29-30 November 1999 the third meeting of the United States Coast Guard Radio Frequency Working Group (RFWG) was held at USCG Command and Control Engineering Center (C2CEN), in Portsmouth, VA.

The RFWG was created to review, discuss, analyze and recommend solutions to problems in the Coast Guard's Maritime Differential Global Positioning Systems (DGPS) RF network. Members of the RFWG include representatives from C2CEN; both the Pacific and Atlantic Maintenance & Logistic Commands; USCG Academy; Civil Engineering Unit (CEU) Oakland; USCG Navigation Center and USCG Navigation Center Detachment.

Topics at these meetings have touched on all aspects of the DGPS RF network including problems with new Automatic Tuning Unit (ATU), ground planes, site radiation hazards and improving tower designs to increase efficiency and decrease "off-air" time. The group has already implemented several changes to the system resulting in improved signal availability and decreased down time. The improvements include the installation of new guy wire insulators, installation of corona rings at the end of the antenna's Top Loading Elements (TLEs); improvements to the ATU and identification of radiation hazards near the broadcast tower. The group is working on a long term review of the best antenna design to maximize antenna efficiency and the creation of RF System PMS Standards and Radiation Hazard Safety Procedures.

The next RFWG meeting is scheduled for July 24, 2000. Any unit is welcome to participate or provide topics for discussion. Questions about the RFWG or requests to review minutes from previous meetings can be directed to C2CEN's POC: LT Dave Godfrey at (757) 686-4076 or email dgodfrey@c2cen.uscg.mil.

LT Dave Godfrey, C2CEN

Nationwide DGPS Status Report

In the past year, the Coast Guard's Nationwide DGPS implementation team has been very busy completing the initial surge installations for the March 15, 1999 inauguration ceremony and preparing for the upcoming expansion. To date, seven sites have been fully converted from their GWEN configurations to transmit DGPS corrections. These sites are located near Chico, CA; Clark, SD; Driver, VA; Macon, GA; Penobscot, ME; Savannah, GA and Whitney, NE. The site at Appleton, WA continues operation in its test configuration and the site near Hartsville, TN operates with a temporary antenna.

As background, the Coast Guard is one of the seven-agency partnership for the Department of Transportation's Nationwide Differential GPS expansion initiative to provide DGPS signals for public safety services. The Coast Guard brings its expertise in building, operating and maintaining DGPS sites to the partnership.

Two major efforts consumed the remainder of the year: 1) transfer of property leases, permits or ownership to the Coast Guard and 2) completion of numerous engineering studies, checklists, and plans to convert these sites to DGPS and to build new sites. Each of these tasks required considerable effort to complete and the property representatives at the Civil Engineering Units and the Maintenance and Logistics Commands and engineers at the Command and Control Engineering Center Portsmouth have done a commendable job getting these tasks completed in the available timeframe.

In addition to these two large-scope activities, the NDGPS project has also begun several activities with other interested partners to build NDGPS sites in areas that did not have GWEN facilities. The U.S. Army Corps of Engineers Pittsburgh District has been instrumental in providing extensive resources including property and engineering time to construct a DGPS site at their lock and dam operations near Hannibal, OH. The Minnesota Department of Transportation (DOT) is identifying property for a DGPS site near Brainerd, MN and the North Carolina DOT identified two candidate properties near Greensboro, NC. Out west, the U.S. Bureau of Land Management has assisted with the identification of two potential sites east of Myton, UT. In Alaska, we have identified potential locations along the rail corridor between Anchorage and Fairbanks for two sites. Site environmental work is underway, with the Federal Highway Administration guiding those efforts.

I know many of you are interested in what sites are going to be installed and when. Currently, the Project has plans to construct 12-14 sites by the end of next year. Some of these sites were already in progress and the remaining ones were selected to provide two coast-to-coast corridors for the Program Sponsor, the Federal Railroad Administration. The northern corridor includes the sites near Medora, ND; Billings, MT; Polson, MT and Spokane, WA. The sites to complete the southern corridor are near Summerfield, TX; Kirtland, NM; Flagstaff, AZ and Essex, CA. Of course the standard caveats apply – no unforeseen delays and subject to funding availability. The sites are listed below in order of planned completion, with tentative completion dates. Since the Coast Guard is still working out contracting kinks and the weather is always an unknown, there is more chance of delays in the northern than southern. In addition to these efforts, two upgrades are planned: 1) at the Hartsville, TN site, contractors will install a full-sized, 300' tower in spring 2000 and 2) the Appleton, WA site may (funding permitting) receive a refurbished equipment hut and final transmitter configuration in the fall. Hopefully we can complete the considerable permit process required for the Trapper Creek, AK site for a summer 2001 installation.

LCDR Gary Schenk, NavCen

Schedule for NDGPS Site Construction CY2000

Billings, MT	1-Jul-00
Flagstaff, AZ	1-Jul-00
Hudson Falls, NY	1-Jul-00
Spokane, WA	15-Jul-00
Annapolis, MD	1-Sep-00
Kirtland, NM	1-Sep-00
Polson, MT	1-Oct-00
Summerfield, TX	1-Oct-00
Greensboro, NC	1-Nov-00
Medora, ND*	1-Nov-00
Myton, UT*	1-Nov-00
Brainerd, MN	15-Nov-00
Essex, CA	1-Dec-00
Hannibal, OH*	1-May-01

* Contingent upon available funding.

Keeping Loran-C Alive

Over the past few years, a cooperative effort between the Coast Guard and the FAA has led to development of system improvements that will enable us to continue the operation of Loran-C. A review of the system over the past several years has revealed critical system components that are nearing the end of their service life. An additional benefit of this review process has been recognition that the integrity and timing of the system can be improved using modern technologies. Coast Guard Loran Support Unit located in Wildwood, New Jersey has dedicated the greater part of their effort over the past two years to projects designed to keep Loran-C alive. Knowing that there is a possible future for Loran-C, the focus of this effort has been to sustain operation and to leverage necessary component replacement into improvements to the system.

Monitor Receiver Upgrade

The Austron 5000 has served as the monitor receiver since the early 1980s. Although the Austron 5000 continues to be a capable receiver, serviceability concerns for the receivers and PDP-8 computers dictate replacement of this monitor suite. Loran Support Unit has identified a receiver manufactured by LocUs as a replacement for both the Austron 5000 and the PDP-8. The capabilities of the LocUs receiver exceed those of the current monitor suite.

ABS

A long delayed project to implement the NAVCOM Automatic Blink System (ABS) units into the Loran-C system is about to be completed. Over the past year, the Coast Guard has installed and tested ABS at all US and Canadian Loran-C stations. ABS is designed to detect short-term timing changes and to automatically initiate blink when the change in timing exceeds 500 nano seconds. In the event of a timing error, ABS will detect the anomaly and begin blink within 3 seconds. The ABS unit will also ensure that blink is continued until the timing error has been corrected. The Coast Guard is scheduled to begin operation of ABS at all stations on 01 June 2000.

UTC Synchronization

Mr. Mike Campbell of Loran Support Unit has developed a Time Of Transmission Monitor (TOTM) suite which allows direct measurement of the daily average time difference between GPS Coordinated Universal Time (UTC) and the transmitted Loran-C signal from the antenna ground return. The measurements obtained using this method have proved to be far less susceptible to noise than measurements obtained using far-field receivers. This new source of data will allow for improvements in control of Loran-C Master timing. The United States Naval Observatory (USNO), with assistance from Navigation Center and Loran Support Unit, has evaluated and validated the new measurement method.

Loran-C Consolidated Control System

Implementation of the Loran Consolidated Control System throughout the U.S. and Canadian Loran-C system has been completed. LCCS is currently being operated at USCG Navigation Center Alexandria, Virginia, USCG Navigation Center Detachment Petaluma, California, USCG Navigation Center Detachment Kodiak, Alaska, and at the Canadian Loran-C Control Center at Fox Harbor, Canada. LCCS leverages efficient use of communication with computer aided system control to reduce the number of Loran-C control watch positions by nearly fifty percent.

LT Lee Putnam, NavCen

Reprieve Granted For Loran-C

Release of the 1999 Federal Radionavigation Plan brings a reprieve for an old radionavigation system slated for termination at the end of this year. The 1999 FRP announced that while the Administration continues to evaluate the long-term need for continuation of the Loran-C radionavigation system, the Government will operate the Loran-C system in the short-term.

Along with this announcement came assurances that the U.S. government will give users reasonable notice if it concludes that Loran-C is not needed or is not cost effective, so that users will have the opportunity to transition to alternative navigation aids.

LT Lee Putnam, NavCen

Looking At Loran-C of Tomorrow

As considerations continue as to the continuation of Loran-C operations into the 21st Century, most of the major points of discussion are familiar to those who have even casually followed the process – Does GPS need augmentations and/or complements? What is the risk of dependence upon a single system? Would Loran-C, operated in concert with the GPS, provide a more comfortable scenario that could lead more readily to international acceptance of the GPS than just asking that sovereign entities rely solely on a U.S. provided service? Can the U.S. financially afford to continue multiple aid-to-navigation services? What are the vulnerabilities of various systems to interference or spoofing?

All the above questions deserve evaluations and answers, but should these considerations take place as either/or choices? And, should we bring into these assessments viewpoints that ask what Loran-C is, or could be today – not what it was ten years ago? Even more exciting could be considering the advantages of combining the dissimilar assets of the GPS with Loran-C, and for some applications, with other navaids and technologies.

To begin with, we should note that various studies over the past decade have shown, for instance, that integration of the GPS and Loran-C can provide 'sole means' capability for enroute, terminal and non-precision aviation operations; and that simply having a Loran-C receiver and a GPS receiver in an aircraft cockpit—not even integrated—would improve the ability of pilots to successfully complete a non-precision approach operation by factors ranging between 100 and 1000. Let's now think about the capability of today's Loran receivers to receive and process twenty or more signals with no limitations as to in which 'chain' the transmitters might be operating. Just think of the increased signal availability advantages. Now let's take the Loran transmitters and synchronize them to GPS time standards (directly or by calibrated references). Now we can look to processing 20-30 signals in a precise time-of-emission mode. Then we can go a step further and recognize that the GPS signals do not include a real-time integrity message—which fact, of course, negatively affects availability and further realize that the GPS signals are sometimes deliberately distorted for national security reasons. To compensate for these GPS shortcomings, we can use the Loran-C signals as a communication channel to provide to the users GPS integrity and differential correction messages. We simply superimpose those messages as modulation on the Loran-C signals in a manner so as not to negatively affect the basic navigation function, but which messages can be simply demodulated in a slightly modified Loran-C receiver and passed on in a standard RTCM format to any suitably equipped GPS receiver. Such signals imposed on the Loran-C signals are in operation today at the Loran-C station at Sylt, Germany under the technical direction of the University of Delft in The Netherlands. This capability known as Eurofix® – which has also been demonstrated from the USCG Loran-C station at Wildwood, NJ – will soon be operational at all European Loran-C stations. One can consider this capability as similar to WAAS/EGNOS and beacon DGPS.

We have to stop now and think of what can be done with 20-30 signals; integrity messages for both the GPS and Loran and differential corrections for the GPS – and if desired for the Loran-C; as well as the flexibility to provide other types of messages, such as weather or emergency situations, particularly when the deliberate distortions of the GPS go away. With everything working together, the corrected GPS data could be used to locally calibrate the Loran-C.

Combined GPS/Loran receivers have been shown to operate effectively in areas where either of the systems alone has had limitations, such as in urban canyons, under foliage, and, to some extent, inside structures.

Another recent receiver-related development is magnetic field (H-field) antennas. These units are simply wire-wound magnetic elements whose outputs are combined in the necessary phase relationship. These units eliminate the historic 6-8 foot whip antenna, provide significant improvement in 'P-static' performance, and do not require an electrical ground. Today's development level is a one inch by one inch by one-half inch structure with a GPS antenna embodied within it. Actually, it could be a DGPS beacon antenna, a GPS antenna, a Loran-C and Eurofix antenna – which is all contained in a hand-held unit.

So, if all these above things are possible if Loran-C operations continue, are there other thoughts that might apply? Sure! How about unmanned Loran-C transmitter sites with new timing and control, and integrated with GPS signal monitors such as those presently envisioned for the WAAS. Or, from the military point of view, one might consider transportable Loran equipped with randomized signal formats for additional anti-jam capability, as well as

(Continued on page 14)

Loran-C Ops Manual Hits the Street

The Loran-C Operations Manual, 1st edition, is on the street. NAVCEN Instruction M16562.1, Loran-C Operations Manual, will supplement COMDTINST M16500.13, Aids To Navigation Manual, Radionavigation. The new manual establishes policies and procedures necessary for operation of the Long-Range Navigation service.

The need for this manual has been evident for several years. Reorganization of Loran-C Operational Control into one command at the Navigation Center resulted in elimination of Regional Managers, which were formerly located within the Atlantic Area and Pacific Area staffs. Obsolescence of the Regional Managers Supplemental Instructions (RMSI) was one impact of this reorganization. This created a void that desperately needed to be filled.

The team that developed the manual had two goals: to bring together the information necessary to effectively operate the system and to present that information in a well-organized easily accessible fashion. In the earliest meetings the development team sought the counsel of the end users of the manual. Officers In Charge, Chain Operations Control Officers, system controllers, maintenance technicians, and managers of the system all played a part in defining what the manual would become.

Organization of the manual is split into two parts. The first volume contains descriptions of the system, organization of the command, control, and support structure for the system. It also contains the procedures for operation of the system during normal, abnormal, and casualty periods. The second volume contains an appendix devoted to items that change at irregular intervals, such as Operation Orders. The appendices also contain job aids and technical guidance.

The manual has been laid out in the Info Mapping format. This format has recently become popular and is used in many of the Coast Guard correspondence courses. The format lends itself to the presentation of material in small discrete portions. Wherever possible charts, tables or graphs are used to organize data and improve the presentation. Topics are treated in a very succinct manner, thus improving the readability of the material. An effort was made to make this manual usable. The organization of the chapters, extensive indexing, and a thorough glossary should help to make this a reference manual for the system

Once you get past the organization and layout of the manual, you will find that there are some changes in the way that we want the system to operate. The most notable of these is in Chapter 7, Casualty Recovery. Take a close look at the Casualty recovery flow charts. There is a fundamental change there. The Control Station now has responsibility for stopping blink in nearly all cases.

We intend to update the manual on a regular basis. Currently the plan is to meet annually to discuss and develop changes. With that in mind, we need your help and your input. When you find a problem or have a suggestion that may improve the manual, let us know what it is. Our goal is to keep the manual current and to always look for ways to improve upon it. Your input will be invaluable in that effort.

LT Lee Putnam, NavCen

Loran-C Moves into 21st Century

(Continued from page 13)
messaging—or maybe shift the frequency off 100 kHz and use the inter-group time for sending communication messages. Just ideas and I'm sure the readers will have many more. The way to think is that today's Loran-C is 'not your mother's Loran-C' any more than today's telephone is your mother's party-line phone.

In the early 1970's the USCG took the courageous decision to put Loran-C in place as a national asset. This decision not only resulted in extraordinary improvements in the safety of operations, but in the establishment of an industry that encompassed over 2 million receiver installations and more than two billion dollars return to the U.S. economy which, in turn, is estimated to be 60,000 job years. An achievement to be proud of on this the 25th anniversary of Loran-C being named an official U.S. aid-to-navigation service. A decision to combine the capabilities of the GPS and Loran-C will provide an even larger opportunity for national and international safety and economic opportunity in the future.

Mr. Edward McGann, Megapulse, Inc.

Rockets In Kodiak

- or -

What Would You Do If Your Loran Station Had A Neighbor That Launched Big Rockets?

It all started with a call from our Coordinator of Chain Operations (COCO) in Kodiak. He asked if we knew about the new launch facility being planned in Kodiak. We asked what type of vessels would be launched - what else do you launch in Kodiak? He said it wasn't a vessel launch facility, it was a rocket launch facility, and it would be built right next to our Loran Station at Narrow Cape. Then the fun began.

The plan was to build a facility to launch rockets used to place commercial satellites into orbit. Since many of these satellites are placed in a near polar orbit, a northern site was desired. A public corporation know as the Alaskan Aerospace Development Corporation (AADC) was formed to plan and develop the facility, and the location chosen was on the property adjacent to Narrow Cape on Kodiak.

We started by meeting with legal, property & technical experts to plan a strategy. We brainstormed a long list of issues that could impact our operations. Things like: their signals affecting our reception, our signals affecting their comms and rockets, access to the station during launches, transporting rockets and fuel along the winding road to Narrow Cape affecting our travel to the station, power line installation near our tower, use of station facilities, seismic affects to our equipment, liability issues....

We then began corresponding with AADC to inform them of our concerns and work with them to mitigate any problems. We reached concurrence on all the major issues, and we are now entering negotiations to develop a Memorandum of Agreement with them on the main points.

Construction of the facility has begun, and we expect the first launch to occur later this year. Check future issues of the Radionavigation Bulletin for an update on concurrent Loran and Rocket operations!

Lou Skorupa, CDR (Ret.)

[Editor's note: although this article was provided to RNB in 1999, we felt the content still worthy of printing in this issue.]

Contacting the NIS

Internet:
http://www.navcen.uscg.mil
ftp://ftp.navcen.uscg.mil

E-Mail:
nisws@smtp.navcen.uscg.mil

Fax On Demand (FOD):
Telephone: (703) 313-5931/5932

GPS Status Recording:
Telephone: (703) 313-5907

WWV/WWVH Radio Broadcast:
WWV broadcasts by telephone or radio at 14-15 minutes past the hour and WWVH at 43-44 minutes past the hour. Radio frequencies: 2.5, 5, 10, 15, & 20 MHz.
Telephone: (303) 499-7111

Coast Guard Customer Infoline:
Call Infoline operators for information on boating safety recalls, to report possible defects in boats, to comment on USCG boarding procedures, for answers to boating safety questions, or for boating safety literature.
Telephone: (800) 368-5647

Write or Call:
Commanding Officer (NIS)
U.S. Coast Guard Navigation Center
7323 Telegraph Rd
Alexandria, VA 22315-3998
Telephone: (703) 313-5900
Fax: (703) 313-5920

Loran-C Recapitalization Project… What's All the Talk About?

Background

The United States Coast Guard has a long history of involvement in establishing and maintaining the Aids to Navigation (AtoN) infrastructure of the United States. Technological advances and Congressional language in the 20th Century expanded the Coast Guard's role in providing AtoN to include radio navigation aids. The most robust and reliable of the Coast Guard's radio navigation systems has been, and continues to be, the Loran-C Navigation System. The ascendancy and pervasiveness of the Global Positioning System (GPS) and its augmentations hastened the decision to terminate other radio navigation systems, including Loran-C. The decision has been re-evaluated based largely on recent instances of GPS jamming and interference, user support and Congressional programming.

In 1996, Congress directed the Department of Transportation, in cooperation with the Department of Commerce, to submit a plan defining the future use of and funding for operations, maintenance, and upgrades of the Loran-C system. To assist with this task, DOT contracted with Booz-Allen & Hamilton (BAH) to conduct an independent assessment of the proposed phase-out of Loran-C and to provide suggested transition and funding alternatives for continuing and upgrading the system. The BAH study identified strong user support for the continuation of Loran-C beyond the currently scheduled phase-out date of December 31, 2000.

Starting in Fiscal Year (FY) 1997, Congress, via the FAA, provided funding to the Coast Guard to modernize and upgrade the North American Loran-C System. Between FY 1997 and FY 1999, more that \$10.2M was transferred to the Coast Guard to execute 21 Loran modernization and upgrade projects. Another \$11.25M is expected in FY00, which is the foundation funding for the Loran Recapitalization Project. The brunt of the planning and execution of these projects has been borne by the Loran Support Unit (LSU) located in Wildwood, NJ.

Why Recapitalize the Loran-C System?

This project will modernize the Loran-C radionavigation infrastructure in order to preserve operations as a transition system through at least 2008. In the future, the goal may be to reduce or completely eliminate personnel at the Loran Transmitting Stations, greatly reduce all required equipment maintenance, and eventually outsource all maintenance, operations, and depot repair of the entire Loran System if deemed necessary for continuance. System performance and safety of the Loran System cannot be sustained without major modernization beginning in FY00.

The eleven U.S. operated 1950's era, labor intensive, vacuum tube transmitters constitute the highest risk factor. The vacuum tube transmitters are particularly problematic, both to quality of operations and to safety of servicing personnel. Vacuum tube transmitters effect approximately 80% of the Loran coverage in the continental United States and ALL of the Loran coverage in Alaska. The failure of a tube transmitter at any one of several tube type Loran Stations would have a significant effect on Loran coverage. For example, loss of the tube transmitter at Dana, IN would eliminate coverage for the entire Midwest and a large portion of the Atlantic seaboard for the duration of that failure. Failure of the tube transmitter at Fallon, NV would have a similar effect on West Coast coverage. Loss of St. Paul or Kodiak, AK would eliminate coverage in the Northern Pacific and Gulf of Alaska, respectively, including all aviation coverage. Several of these particular tube transmitters are already experiencing insidious problems and our support prsonnel are putting in tremendous extra hours to keep these pieces of equipment working.

Many experienced Loran personnel are also reaching retirement age or transferring out of the Loran field. This decreasing knowledge base increases the risk to personnel and to system operations. The age of components making up the Loran System has placed an ever-increasing workload on Coast Guard personnel. In the past 30 months, the Loran system has required an unprecedented 115 technical assists by LSU alone to avoid unusable time. These assists resulted in 16 Crisis Contingency Projects and 29 Engineering Change Proposals/Orders.

Current Status

The $110M LRP effort has been designated as a non-major systems acquisition. On 8 November 1999, a project staff consisting of ten new positions was approved, with the majority of the positions located at the Loran Support Unit. Figure 1 shows the make-up of the LRP team. In addition to the actual LRP staff, LSU is working closely with G-SEC, both Maintenance and Logistics Commands, District Seventeen, the Coast Guard Academy, Training Center Petaluma, the Navigation Center (NAVCEN), Facilities Design and Construction Center (FD&CC) Pacific, the FAA, and several Electronic Support Units (ESUs) and Civil Engineering Units (CEUs) to get this project off the ground. LSU also has four contract personnel onboard with more than 100 years of combined Loran experience to provide invaluable technical assistance.

Title	Rank/ Grade	Location
Project Manager	GS-15	LSU
Deputy Project Manager	O-4	LSU
Technical Director	O-4	LSU
Assistant Technical Director	O-3	LSU
LPM/Project Engineer	O-3	LSU
LPM/Project Engineer	GS-12	LSU
Operations Director	O-4	G-OPN-3
Systems HQ POC	O-3	G-SCE-2
Program Resources Specialist	GS-07	LSU
Contracting Officer	GS-13	G-ACS-5

Figure 1: LRP Staffing

As a result of interagency agreements between the USCG and FAA, LSU has been recapitalizing Loran since 1997. Every project completed has been a stepping-stone for Loran recapitalization. Since LRP funding will be coming to the Coast Guard in piece-meal fashion and could be stopped at any time, this "new" effort will treated the same way, only on a larger scale. In order to keep the scope of the LRP initiative manageable, the LSU has broken up the project into several smaller sub-projects. Below is a list of past, current, and future projects that fall under the LRP umbrella:

Tube-Type Transmitter Replacement at 11 locations

Completion of the Automatic Blink System (ABS) Project

Replacement of the Monitor and Casualty-Recovery Loran Receivers

Completion of the Loran Backup Communications Project

Completion of the Loran Consolidated Control System (LCCS) & Monitor/Casualty Receiver Interface

Completion/Testing of the Prototype Automated Loran Station (PALS) Concept

Completion of Solid State Transmitter Switch Cabinet Modifications

Completion of the Remote Automated Integrated Loran (RAIL) System Project

Replacement of Cesium-Beam Frequency Standards

Replacement of the oldest version Transmitter Operational Controllers (TOPCOs)

Loran Data Channel Communications Analysis

Replacement of Loran Timing and Frequency Equipment

Completion of the Loran Time-of-Transmission Project

Significant Civil Engineering efforts: buildings, runways, and towers

For More Information: Contact LCDR Al Arsenault at (609) 523-7349 or via email at aarsenault@lsu.uscg.mil. Individual project status can be accessed via the LSU Web Page at http://www.uscg.mil/hq/lsu/webpage/projects.htm.

LCDR's Chuck Schue & Al Arsenault, LSU

Modernizing the Loran-C System for the New Millennium

Background

The Loran-C system can be looked at as a system with three major components, each with its own suite of equipments. The first component is the Loran Station (LORSTA), which consists of the timing and transmitting equipment needed to transmit the Loran signal to the user. The second component is the Primary Chain Monitor Set (PCMS) site, which consists of monitoring equipment necessary to ensure the Loran signal seen by the user is within published tolerances. The third component is the Control Station, which consists of command and control equipment that is operated 24x7 and remotely connects to the LORSTA equipment and PCMS equipment for a Loran chain. As the SMEF for Loran-C, the LSU is heavily involved with modernizing and upgrading these components for the new millennium.

Current Project Status

The Control Station equipment was the first component in the Loran-C system that LSU tackled to modernize and it came in the form of the Loran Consolidated Control System (LCCS). The LCCS is a computer-based system that provides remote command and control of the Loran-C system. The computer consists of an HP9000/J210 series workstation running the HP-UX 10.10 UNIX operating system. The LCCS application was developed in house with contractors and LSU personnel, "blue-suiters" and civil service alike, working side by side. It is written in C++ and uses the Informix Database Engine for data storage. Once LCCS was fielded, the contractors used during the software development were phased out. Now LSU personnel are solely responsible for the maintenance and upgrades to the LCCS application, the UNIX system administrator functions and the Informix database administrator functions. In December 1998, the last Control Station (Kodiak), switched to the LCCS.

Now the emphasis to modernize the Loran-C system has moved to the other components in the Loran system. The PCMS suite will be modernized by LSU before the end of FY00. Since there were no commercially available Loran receivers that met the U.S. Coast Guard requirement, a Small Business Innovative Research (SBIR) contract with Locus, Inc. was used to design a new Loran receiver. The Locus LRS-III D receiver is the outcome of this contract. LSU is currently conducting first article testing on this receiver. The production model receivers are scheduled to be delivered 3rd quarter FY00. The Locus LRS-III D receiver will replace antiquated Austron 5000 and the 1965 PDP-8 octal computer. In addition, the Elgar 102 UPS will be replaced with a Clary DT800R UPS. Figure 1 contains pictures of the present and future PCMS equipment rack.

There will be many benefits realized with the new PCMS equipment, including:

> Reliability and availability will increase from the increased Mean Time Between Failure (MTBF) with this new technology.
>
> There will be a significant improvement in performance. The Locus LRS-III D receiver is a multi-chain receiver that uses a patented linear averaging digital filter, which significantly reduces the cross rate interference (a major source of noise in Loran signals). The Locus LRS-III D receiver provides additional data information and remote control capabilities, such as, automatic notch filters, remote spectrum scans, and a primary power loss alarm.
>
> The annual maintenance, support and training costs will decrease. With the current PCMS equipment, the Lowest Repairable Unit (LRU) is at the board level and requires a local technician to be familiar with programming the PDP-8 using dip switches. With the new PCMS equipment, the LRU is the receiver itself. This dramatically simplifies the maintenance and troubleshooting required by the local technician. In addition, this reduces the need for lengthy, formal training on the PCMS equipment.

Numerous multi-year projects have been started within the last year at LSU to modernize the LORSTA component of the Loran-C system. Work is well underway to prototype the Remote Automated Integrated Loran (RAIL) system, which is currently being developed in house. In fact, the RAIL Phase I prototype was recently installed at LORSTA Jupiter for a field test. The RAIL system is a computer-based system that provides remote (via LCCS) and local command and control of LORSTA equipment. The computer consists of a 400 MHz Pentium II with various cards installed that provide analog/digital conversions, time interval counter functions, and that expand the number of RS-

232 ports to 16. The operating system is Windows NT Version 4.0 and the RAIL software is written in Visual C++ with Roguewave Tools and Lab Windows/CVI Version 5.0.

LSU is involved in all stages of the development of the RAIL prototype system. This includes working with the operators to determine requirements, selecting appropriate hardware/software to meet those requirements, developing the RAIL application, which includes designing the Graphical User Interface (GUI), and lab and field testing the hardware and software. Since the RAIL system interfaces with a variety of equipment at a LORSTA, some creative engineering is required during the development and installation to ensure the operational impact is minimized. In addition, enough capability and flexibility must be designed in the system to meet the needs of new equipment that will be installed in the near future.

The RAIL system is being designed to integrate the various equipment installed at a LORSTA and automate as many functions as possible. By default, RAIL becomes the local command and control system for the LORSTA and the remote interface for LCCS. Here are some of the items being designed into the RAIL system:

Replace the CGSWII Teletype

Provide digital charts (replaces up to 14 mechanical, chart recorders.)

Replace the Local Site Operating Set (LSOS) Time Interval Counter

Interface with the recently installed Automatic Blink System (see below)

Interface with the Time of Transmission Monitor to be installed in FY00

Interface with the new Cesiums to be installed in FY00/FY01

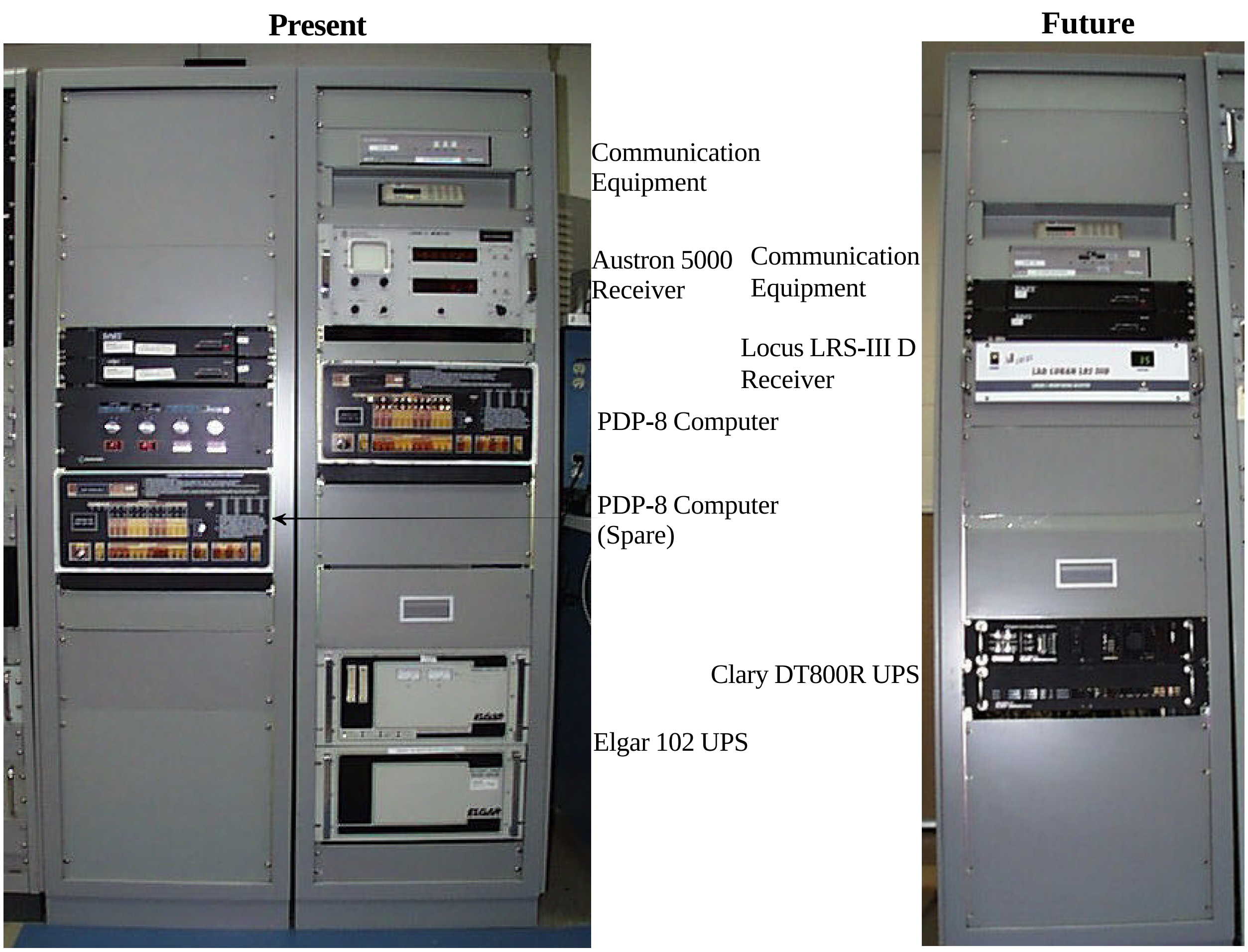


Figure 1 - Present and Future PCMS Equipment Rack

(Continued on page 20)

(Continued from page 19)

Interface with the new Locus receiver (which replaces the Austron 2000) to be installed in FY01/02

Archive all data electronically

Interface with and then replace the LSOS computer

As one can see, the list is pretty extensive. The variety of equipment that the project staff deals with makes the project very interesting. This is particularly important since the RAIL system must be designed to interface with equipment built and installed during different periods over the last three decades. Examples of the prototype GUI screens are shown in Figure 2 and Figure 3. The RAIL Home Screen provides a complete picture of the current status of the LORSTA equipment. This screen contains all the data and alarms that must be monitored and a user can navigate to other screens that provide additional details. For example, if a user wanted to view the "Master Minus Local," or MAS-LOC, chart to see the time difference between the master and local signal, they would double click on the DELTA MAS-LOC icon and the RAIL Delta Receiver Screen (Figure 3) would appear. This screen provides additional data regarding the MAS-LOC data. From this screen, a user may adjust the tolerances for alarms, view the last hour of data on a digital chart and configure the Locus receiver.

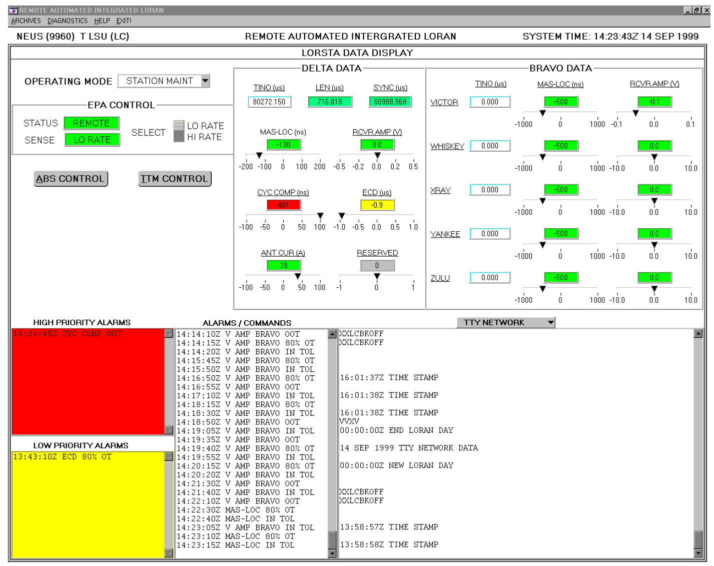


Figure 2 - RAIL Home Screen

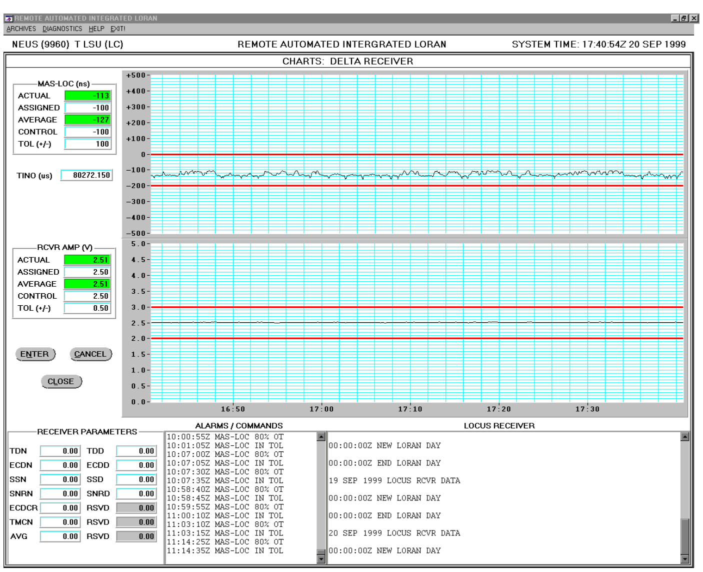


Figure 3 - RAIL Delta Receiver Screen

Although Loran-C has been around for many years and may be considered old technology, the work currently being done in Loran is using the latest technology available. Many of the projects being worked on at LSU would not have been possible five years ago. It is only due to the advancement of technology and willingness to push the envelope, that we've been able to apply this new technology to the Loran-C applications. This modernization of the Loran-C system will make it cheaper, easier and simpler to maintain and operate Loran in the new millennium.

For More Information. Contact LCDR Jim Koermer at (609) 523-7247 or via email at jkoermer@lsu.uscg.mil. Individual project status can be accessed via the LSU Web Page at http://www.uscg.mil/hq/lsu/webpage/projects.htm.

LCDR Jim Koermer, LSU

Automatic Blink System & Prototype Automated Loran Station

Background

Two of the projects that the transmitter branch at the LSU is involved in are the Automatic Blink System (ABS) and the Prototype Automated Loran Station (PALS).

The U.S. Congress mandated that an Automatic Blink System be installed at all LORSTAs providing navigational coverage within the National Air Space (NAS). The Federal Aviation Administration (FAA), as the lead U.S. agency for aviation navigational matters, was provided funding for the development of this system.. The FAA then requested Coast Guard assistance to perform the installations. The Automatic Blink System Project Team at the LSU has installed ABS at all 29 North American Loran-C LORSTAs and at the TRACEN Petaluma Loran-C Timing and Control Equipment classroom.

ABS provides a signal integrity indication to Loran-C receivers. Signal integrity involves notifying the user through either "blinking" a secondary LORSTA or taking a master LORSTA "off air". ABS will provide user notification of Time Difference (TD) signal aberrations in less than two seconds. This is especially important to aviation users because of their speed of travel.

Secondly, the LSU is reactivating the Prototype Automated Loran Station (PALS) project. The PALS project was halted in FY99 because limited LSU resources were redirected to higher priority projects. The purpose of PALS is to develop and test at one or more operational units those techniques, procedures, policies, equipment, systems, or infrastructure changes needed to reduce the operating costs of a LORSTA through automation. PALS will study the feasibility and determine the capability of automating the routine functions of a LORSTA. The primary goal is to identify methods that reduce the operational costs while maintaining required reliability and availability to the user. The key areas to be addressed are station administration, operations, Loran electronics, security, and facility maintenance.

ABS Current Project Status

The ABS project began in 1998 with a field tests at LORSTAs Boise City, OK, Havre, MT, and Searchlight, NV using ABS units developed by NAVCOM, Inc. As a result of the field tests, the NAVCOM ABS units (Figure 1) were selected for installation during FY99 pending several changes to the internal software.

LSU personnel then spent a very busy year travelling to every LORSTA in the North American system. It was a lot of hard work, travel, and fun all at the same time. We intentionally planned to visit the southern stations in the winter and the northern stations in the summer - who would choose to visit Port Clarence for a week in December! A juggling of the C-130 logistics flights to Attu Island allowed us to spend only a week on the isolated island instead of the two weeks normally dictated by the flight schedule.

Figure 1 - NAVCOM ABS Unit as installed at LORSTA Havre, MT.

The ABS installation was normally a three day process with two scheduled Authorized Unusable Time (AUTM) periods. On the first day the ABS units were installed in the timer racks; all cables were installed, routed and labeled; the timers were modified; and the TTY communications routed through the ABS unit. On the second day, the Timer Set Controls and the 5MHz paths were modified; the 5MHz Distribution Amplifiers readjusted; and the ABS units initialized and programmed for the specific station. On the third day, the ABS installation was certified and the station crew given ABS training.

We actually began and finished the ABS installations without the final software changes because of funding considerations. The new software development is in progress and should be available soon from

(Continued on page 22)

(Continued from page 21)

the FAA. LSU will provide replacement EPROMs to the field once the new software has been successfully tested. The installed ABS units were left in a hardware bypassed state until the new software can be installed. In this condition the Loran-C signal passes directly through the ABS unit untouched. The ABS unit monitors and evaluates the signal but does not start blink even when an out of tolerance is detected.

PALS Current Project Status

LSU has moved towards a field test of PALS at Loran Station Jupiter. Our goal is to begin the test in FY00. The field test could last up to six months, after which the station will be returned to its normal configuration. LSU is already using Jupiter as a test site for equipment upgrades that make PALS possible. This includes:

Electronic charts are being field tested to replace the maintenance intensive paper charts for displaying and recording the station signal parameters. The electronic charts are part of the Remote Automated Integrated Loran (RAIL) system under development.

An Automatic Blink System (ABS) has been installed to provide signal integrity.

Wireless Back-up Communications to the Loran-C Consolidated Control System (LCCS) has been installed for increased remote control availability.

Local Site Operating Set (LSOS) software has been modified to provide cesium drift data to allow the removal of the maintenance intensive dedicated Linear Phase Recorders.

Uninterruptable Power Supplies (UPS) will be field tested to provide consistent quality power to the Loran electronics and transmitter.

New HP-5071 cesiums will replace the older HP-5061 cesiums as the frequency standard.

In addition to these equipment improvements, a draft Operational Order will be developed, and the station buildings' maintenance and security will be evaluated for unmanned support.

For More Information. Contact LT Steven Dyer at (609) 523-7270 or via email at sdyer@lsu.uscg.mil. Individual project status can be accessed via the LSU Web Page at http://www.uscg.mil/hq/lsu/webpage/projects.htm.

LT Steven Dyer, LSU

CGSIC 36th Meeting Announced

Sept. 17 - 19, 2000

Salt Lake City, Utah

—————-

Registration and hotel information are available at the Navigation Center website:

www.navcen.uscg.mil/cgsic/meetings

FRP 10th Edition Released in 1999

The U.S. Department of Transportation and U.S. Department of Defense jointly released the 1999 Federal Radionavigation Plan recently, which includes plans for two additional GPS signals for civil use and a revised schedule for making the transition to GPS.

To support the development of the 2001 FRP, DOT & DOD are sponsoring an FRP User Group Meeting on 29 June in San Diego, CA.

To obtain more information on the User Group meeting or to obtain free copies of the 1999 FRP, contact the Volpe National Transportation System Center, Kendall Square, Cambridge, Mass. 02142, telephone (617) 494-2908. The FRP is also available on the Internet at www.navcen.uscg.mil/frp.

Backup Communications & Loran-C Data Channel Communications

Background

The LSU recently fielded a Backup Communications (BUC) system to provide a contingency communications option throughout the North American Loran-C system. If primary communications is lost at a LORSTA, then the contingency system will allow the Loran Consolidated Control System (LCCS) to continue seamless remote control and monitoring of the Loran station and transmitted signal.

Current Project Status

The latest in cellular and satellite technology was used to develop the system. Three versions of the system exists: GCF-LN-BUC(V)1 is a dedicated land line configuration for use in areas where cellular or satellite communications are not feasible, GCF-LN-BUC(V)2 is a cellular configuration for use in areas where cellular service is available at the control station and all Loran-C transmitting stations in the chain, and GCF-LN-BUC(V)3 is a satellite configuration for use in areas where cellular service is not readily available.

This system (Figure 1) provides an alternative communications path to the landline Loran Packet Switching System (LORPSS) used for primary communications. A modem or dedicated landline for each rate is installed at all Loran stations to provide a data link with the Local Site Operating Set (LSOS). The modems at the control station provide the data link to the LCCS. The control station modem is then linked with the Loran station modem creating a data connection. The control stations have enough modems or dedicated landlines installed to simultaneously control two Loran stations for each Loran-C chain during a primary communications outage.

LSU is currently working on a project to develop a communications system that allows data broadcasts on the Loran-C signal. The possibilities are exciting as the data transmissions can be used to provide a contingency data channel to LORSTAs. This system would be much cheaper than using the Backup Communications system because there would be no service provider costs. Working closely with the U. S. Coast Guard Academy, Stanford University, and the FAA, LSU is testing possibilities to increase the information bandwidth that could allow other data transmissions on the Loran signal.

(Continued on page 24)

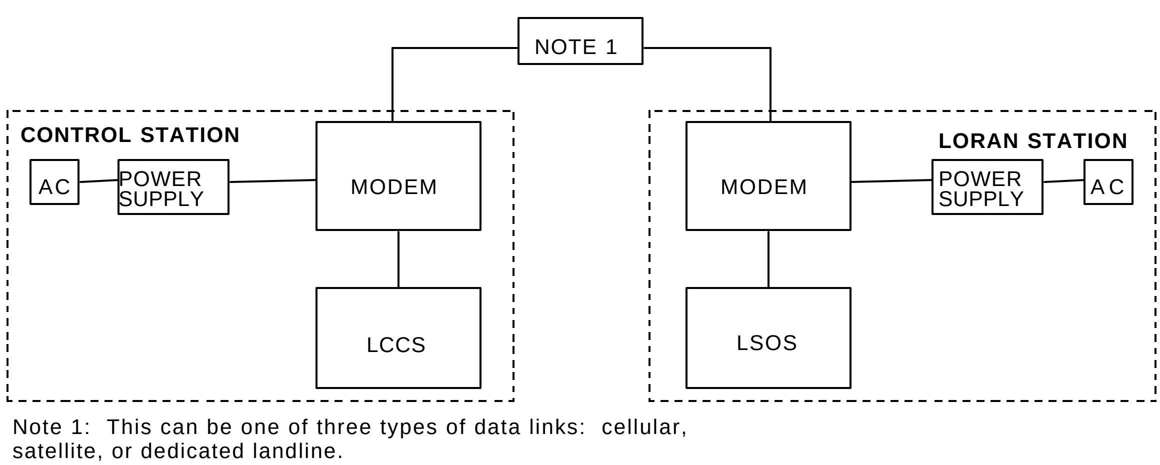


Figure 1 - Backup Communications Block Diagram

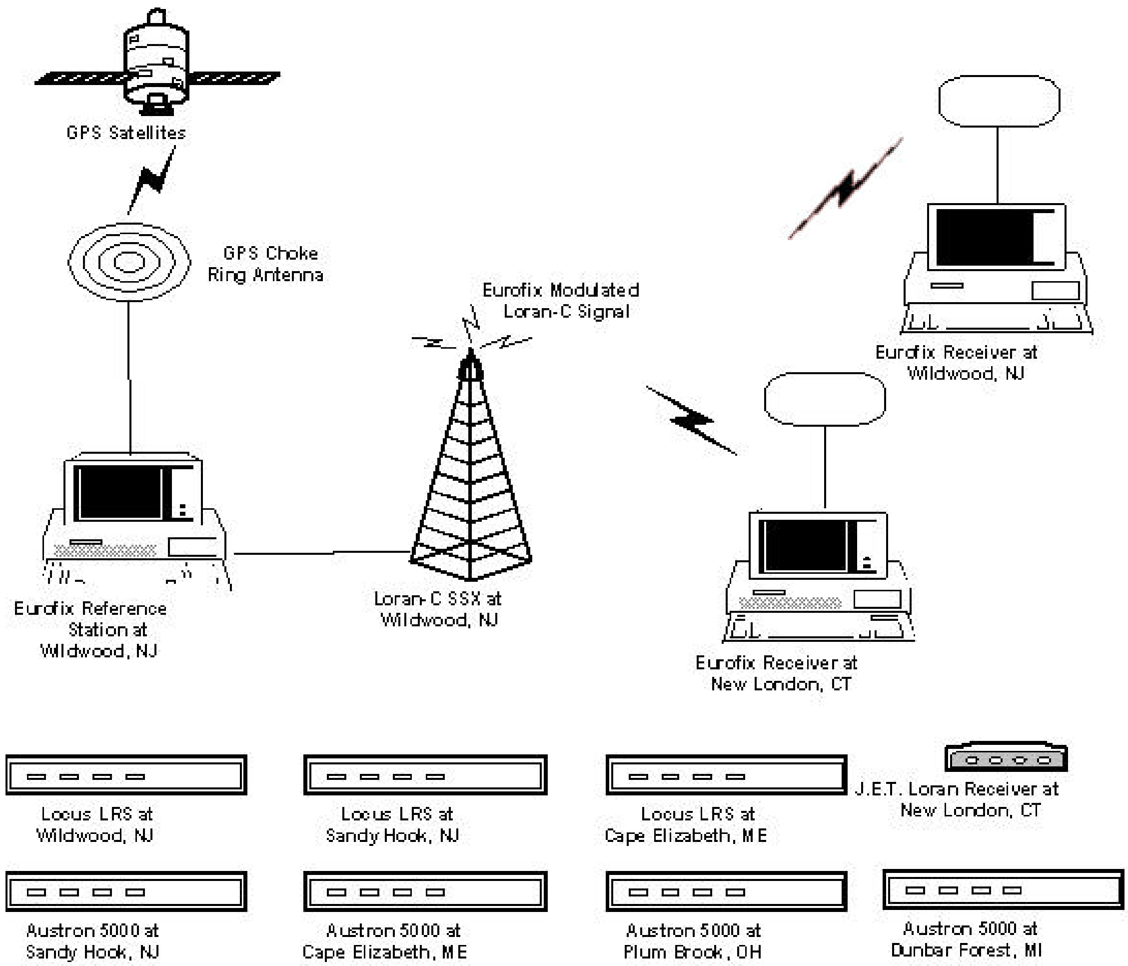


Figure 2 – Eurofix Test Plan

(Continued from page 23)

Data communications are not new to Loran. Two Pulse Comms and Clarinet Pilgrim were two systems used in the past to transmit data. Presently, in Europe, the Loran system is used to transmit dGPS correction data. This system is called "Eurofix" and was tested at LSU by LSU and U. S. Coast Guard Academy personnel. The test configuration (Figure 2) developed by LT Stephen Bartlett, USCG, used the latest in satellite receiver technology and modulation & encoding schemes to prove that advanced technology can be used to develop a robust data communications system using the Loran-C signal.

The benefits of using the latest in satellite receiver technology and modulation & encoding schemes will be increased reliability and accuracy of the Loran-C system at a lower cost. Although many believe that the Loran system is antiquated and obsolete, these initiatives show that LSU and the U. S. Coast Guard are at the cutting edge of technology.

For More Information. Contact LT Jim Betz at (609) 523-7277 or via email at jbetz@lsu.uscg.mil. Individual project status can be accessed via the LSU Web Page at http://www.uscg.mil/hq/lsu/webpage/projects.htm.

LT Jim Betz, LSU

Supporting Coast Guard Engineering Efforts While Still in Graduate School

This past summer I worked with four other Coast Guard graduate school students in electrical engineering at the University of Rhode Island (LT Eric Bruner, LT Dan Pickles, LTJG Rich Pokropski, & LTJG Mike Edwards) in support of a Coast Guard initiative to understand how to transmit data using the Loran signal. The project, called pulse position modulation, involved trying to understand using current technology how to modulate six of the eight Loran pulses to transmit the data. The format we worked on applied advance or delay time shifts, or no shifts (a prompt) to transmit the data. To those of you that have been around for a while in the Loran world this may sound a lot like Two Pulse Communications or the Clarinet Pilgrim program. Well, you would be correct. It is very similar to those programs, but uses current technology. None of us students had any experience in Loran except as an end user, so everyone had to first learn the basics of how Loran worked. Here the Loran Support Unit in Wildwood, NJ and the electrical engineering department at the Coast Guard Academy were of great assistance, providing manuals and a wealth of technical information.

Once we had some understanding of Loran we went about figuring out how to modulate data so that it could be transmitted, and trying to learn a code that would ensure the data received was the same as the data transmitted. For the latter part we did research into Reed-Solomon encoding. This type of encoding is almost bullet proof when it comes to ensuring the transmitted data is received correctly, but at the expense of a lot of bandwidth. With some valuable input from the staff at the Academy we figured out how to do the modulation portion of the project.

For the remainder of the project time we focused our efforts on using Matlab (an engineering based software) to simulate encoding data using a Reed Solomon code. For practical purposes we simulated a 63-bit dGPS data stream. We wrote three different software programs, each one an improvement over the previous.

The final program took a seven bit binary word and converted it to a decimal word ranging from 1 to 127. The code then did a table look up to determine the corresponding 6-trit word. A trit is a trinary word that effectively represents an advance, delay, or prompt in this case. The trits were modulated to represent either a one-microsecond advance or delay, or neither to represent a prompt. The trits were then demodulated by taking the incoming trits and recombining them to compute the angle of the trits. The distance from the decision boundaries for the three areas (advance, delay, & prompt) were then computed to determine which area the value is placed in. It then determined if the incoming trit is a valid trit by comparing it to the table lookup. If it is not a valid trit, the metrics computed determines the closest valid six-trit word, then decodes the closest six-trit word.

At this point erasures and errors would be addressed utilizing the Reed-Solomon code. We needed a custom version of the Reed-Solomon code since the basic version we utilized in Matlab is not designed to perform this function. But our summer session came to an end and so did our project. Everyone involved learned a great deal about potential Loran communications and was able to contribute productively to the Coast Guard engineering effort while still being in graduate school. The support we received from the Loran Support Unit and the Coast Guard Academy was exceptional and more graduate students should seek out and take advantage of those potential partnerships.

LT Jay Boyer, LSU

UNITED STATES COAST GUARD

Navigation Center